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ON AMBLYOPIA FROM DI-NITROBENZOL:

*With Remarks on the Employment of this Substance in
the Making of Certain Explosives, and its Effects
on Those Engaged in the Manufacture.*

BY

SIMEON SNELL, F.R.C.S. EDIN., ETC.,

Ophthalmic Surgeon to the Sheffield General Infirmary;
Consulting Ophthalmic Surgeon to the Rotherham Hospital.

Reprinted for the Author from the BRITISH MEDICAL JOURNAL, March 3rd, 1894.

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AMBLYOPIA FROM DI-NITROBENZOL :

WITH REMARKS ON THE EMPLOYMENT OF THIS SUBSTANCE IN
THE MAKING OF CERTAIN EXPLOSIVES, AND ITS EFFECTS
ON THOSE ENGAGED IN THE MANUFACTURE.

NITROBENZOL is used in the manufacture of aniline dyes and other products. Di-nitrobenzol is largely employed in the making of explosives such as roburite, sicherheit, etc. From the report¹ recently made to the Home Secretary by Dr. Dupré, F.R.S., and Commander Hamilton P. Smith, one of Her Majesty's Inspectors of Factories, it is to be gathered that nitrobenzol is not very injurious to those who work with it, notwithstanding the fact that, taken internally, it is undoubtedly poisonous. Benzol and toluol (coal tar products), treated with nitric and sulphuric acids at moderate temperatures, become nitrobenzol or nitrotoluol; further treated with the same acids at higher temperatures they become di-nitrobenzol or di-nitrotoluol, and assume a crystalline form at a temperature of from 158° to 176° F. The ordinary commercial substance is said to contain impurities some of which are more volatile than the di-nitro, while some are fluid at ordinary temperatures; they thus impart to it a more or less powerful smell resembling that of bitter almonds (due sometimes, but not always, to the presence of nitrobenzol), and render it more or less greasy to the touch, which the pure chemical should not be. The presence of the impure products spoken of increases the danger of working with di-nitrobenzol, not only on account of their vapours, but chiefly because the greasy characters tend to make the substance adhere more when handled, and thus promote absorption. At most of the explosive works the di-nitrobenzol is submitted to some sort of purification, which is necessary to comply with the requirements of the Explosives Department of the Home Office, but does not affect the impurities spoken of. The di-nitrobenzol acts as a poison whether ingested, absorbed by the skin, or inhaled into the lungs in the form of vapour or dust.

The di-nitrobenzol arrives at an explosive factory in slabs, say, of 15 inches square and about 4 inches thick. This is first ground in an apparatus with steam rollers not at all unlike a small mortar machine. In this process a good deal of dust is given off, and the men remark on the smell of bitter almonds. The next step is to take the yellowish powder thus obtained to the mixing shed, where it is put into a large pan,

¹ On the Risks arising and Precautions to be adopted in the Manufacture and Handling of Nitrobenzol and Di-Nitrobenzol.

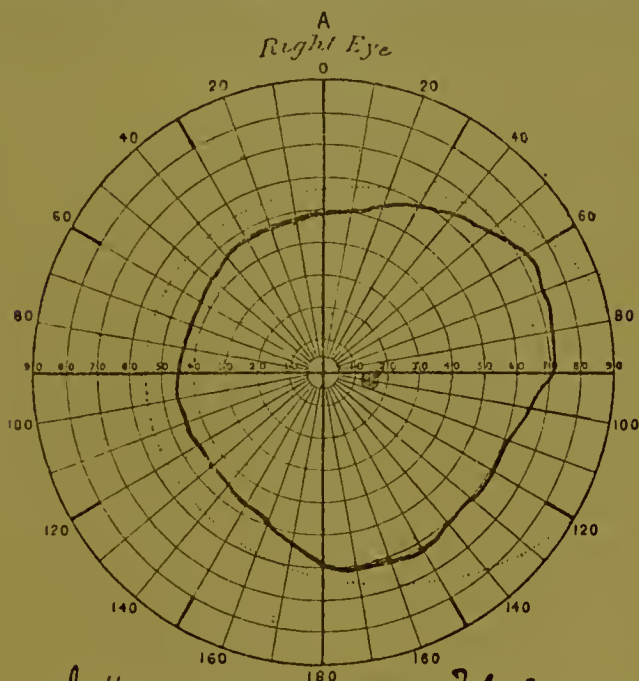
and mixed with oxydising salts and other materials, and heated with steam. It may be put into one of these pans, say, at 7.30 A.M., and be heated until noon. Then it is cooled by cold water being pumped on the outside of the shell. When cool the material is turned out of the "mixer." It is during the taking out of the material from the mixer that workmen are especially exposed to the vapour. The dangers are lessened by the adoption of a "cowl" to the mixer, and also by the use of fans. Thus prepared the explosive is put away in cylinders and kept until required. The next step is to take it to the filling room, where it is put into cartridges, weighed, and stamped, and finally it goes to the dipping shed, where the cartridges are waterproofed by dipping them in liquid paraffin wax.

The most injurious work is that of "grinding" and "mixing," especially the latter. Men are employed in these processes. For the "filling" of the cartridges, and for the dipping also, women and girls are employed. In the first named the powder is shovelled into the cartridges and directly handled; a good deal of dust is also given off. Respirators and gloves are used, as they are also by the men mixing or grinding. The "dippers" are the least exposed to the effects, it would appear, but they do suffer. The greasiness about the hands from the paraffin may also aid absorption. Here also gloves and respirators are worn. There is not much dust, the powder being confined inside the cases.

I will now proceed to detail the cases that have come under my observation suffering from amblyopia.

CASE I.—J. H., aged 35, presented himself on February 11th, 1892. He stated that just before the previous Christmas his sight commenced to fail. On reaching home at night he could not recognise his wife across the table. During the next few days it became much worse, and then deterioration was more gradual. Recently his vision has remained about stationary, and this, as will be explained, has been associated with an alteration of work. Vision in each eye is $\frac{3}{8}$, and he reads J. 16. Both optic discs are decidedly pale; the edges are quite defined, and there is no appreciable diminution in calibre of vessels. The field of vision is somewhat contracted concentrically, and there is a small fairly defined central scotoma for red and green. The pupils are normal in all ways. The patient has been a smoker for twenty years, consuming generally about $1\frac{1}{2}$ oz. a week; he has not been smoking more nor less than usual lately; the kind of tobacco he smokes is cut cavendish. He takes very little alcohol, being almost a teetotaler. His face is pallid, lips bluish, and conjunctivæ yellowish. The finger tips are blue, looking like "cold fingers;" the nails are discoloured, of a fawn colour, darker at the ends, and gradually tapering towards the matrix. The toes are like the fingers, the nails being even more discoloured. The urine was free from albumen; specific gravity 1029; whilst he was engaged in the work to be mentioned it was dark like ink, but it has lately become clearer. The man's occupation properly is that of a blacksmith, but being out of employment and failing to get anything to do at his own trade, he went to work in July, 1891, for a company where explosives, in which nitrobenzol was used, were made. Previously to undertaking this work, he asserts that his health was perfectly good and sight excellent. He was employed at these works in the "mixing shed," and worked there in the way that has been described. He began this three days after joining the works. On the first day he asserts that he felt the effects of the benzol. He experienced giddiness and shortness of breath. A short time later he looked yellowish and his lips blue. The giddiness compelled him to sit down. Gradually he appears to have become accustomed to these symptoms, and he does not seem to have suffered as severely as others to be mentioned. He kept out of the mixing shed as much as he could, and his residence being a good distance from his work he was compelled to take a good sharp walk. These are reasons, he thinks, why he suffered less than others. Before Christmas, however, he became worse; the shortness of breath increased; he tossed about in bed in his sleep, and suffered from great weakness. He experienced a feeling of want of sensation in his arms and legs, and they were "prickly feeling"; the legs were numbed to the knees and the arms to

the elbows; there was a stiffness about the hands and feet, but especially the fingers; he finds a little difficulty in undoing his collar button. The patellar reflex is good (exaggerated?). When "mixing" he suffered from occipital headache a good deal, but has not had any vomiting. Memory, taste, and smell are all good. He was disturbed and restless in sleep, and was troubled with dreams and shouted out. A marked effect had been wrought on his sexual functions. He had lost desire, and he said that his wife told him "he would be no good until he had left off the work." He had not been amongst the powder for about a month. The only other point to mention is that he suffered from an attack of influenza before going to the explosives works. He was desired to avoid all contact from the benzol compounds, and the firm provided an occupation away from these for him. He was prescribed liq. strych. in a mixture. He was desired to continue his smoking precisely as he had been accustomed to do. Progress towards recovery was steady.



The fields of vision in both eyes being closely similar, only the chart for one eye is given in each case.

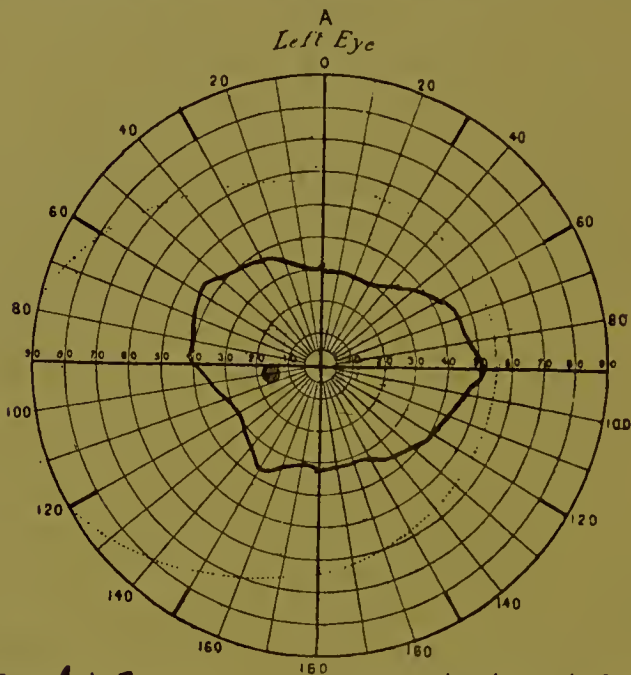
On March 12th $V=1\frac{1}{2}$ in each eye. A few days later he said that his sexual functions were restored to normal. On April 24th $V=2$, and shortly after this he discontinued the strychnine. On May 20th vision still the same, taking no medicine. A final note may be recorded. November 19th no red scotoma, and field of vision good. Vision is excellent, and he reads J1 easily and $V=2$. There is still some pallor of optic papillæ. He looks well, has a good colour, does not suffer from fatigue, and can work as hard as ever he could. He is still a little shorter in breath than formerly, and there is some remaining numbness in hands and toes.

CASE II.—C. W. F., aged 38, came to see me on April 9th, 1892, complaining of defective sight. He had been employed at the same factory as the last patient. He had worked there as a "mixer" off and on for twelve months. His skin is jaundiced and the conjunctiva is distinctly yellow, and the lips markedly blue. He suffers from shortness of breath. After a day's work he experiences aching of forearms and of legs, and also tingling of fingers. Occasionally he has had vomiting and nausea. Sometimes at work, or after leaving it, he has felt as if he were drunk; weak, giddy, and staggering. He cannot drink anything now, because of the greater effect it has on him. His urine is black, specific gravity 1024.

A specimen was examined by the spectroscope, and the result will be referred to further on. He had a pulmonary systolic murmur. His sight had been failing since the previous Christmas, about four months. Vision in the right eye was $\frac{2}{20}$, left $\frac{1}{20}$; both optic papillæ were somewhat pale. In each eye there was a central scotoma for red, and concentric contraction of field. He has been a smoker since the age of 17; for the last three years the quantity he has smoked a week has been $1\frac{1}{2}$ ounce, before that time it was about $3\frac{1}{2}$ ounces a week.

I have not had an opportunity of seeing this man again, but I have heard of him, and have made the following notes from information received as to his subsequent condition:

June 18th, 1892. After he had been over to see me he did very little work with the dinitro. He used it, perhaps, twice a week, but not for a long time together. Then he did "carrying." He left the place at the end of May. He was afterwards asked to go back for a day or two to "mixing," as the man who was employed at that work was too ill from the "powder" to go on with it. One day at "mixing" made him so ill that he could not get his breath. He was raving and unconscious from 5 in the after-



Name C. H. F.

Date April 9. 1892

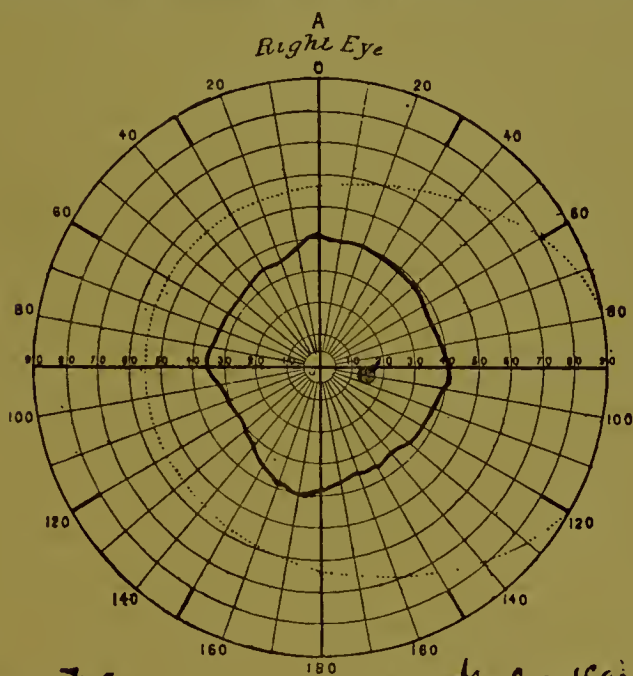
noon to 10 at night. The doctor gave him up, but he recovered. His sight has been much better since he discontinued working at the factory. More recently I heard that he had re-enlisted into the army.

CASE III.—F. E. was seen on April 19th, 1892. He had been a "mixer" at the same explosive works as the cases already mentioned, but had left the place twelve months previously. Since then he had been employed as a labourer at some mills. When working with the nitrobenzol, after a day's labour he often had attacks of giddiness but no nausea nor vomiting. Before going to his work his health and eyesight were both good. After being employed there, however, for about seven months he noticed that his sight was affected. At first he had been engaged in the magazine handling the cartridges, and then he commenced to "mix." It was when he had been occupied with this latter kind of work for about two weeks that his sight became impaired. He relinquished the work altogether, for he feared he would become perfectly blind, and since discontinuing it he states his vision has become better. He has been a smoker for fourteen years, and is as much addicted to it now as ever he was; 2 ounces of "twist" a week is his usual quantity. When his sight commenced to fail he was smoking less because the breathlessness compelled him to do so; he was only at that time smoking about $\frac{1}{2}$ ounce a week. In each V. = $\frac{1}{20}$; the discs are pale, but there is no diminution

in calibre of vessels, and the edges of the papillæ are well defined. The visual field is contracted concentrically, but there is no scotoma for red. When working with the benzol he suffered from breathlessness, pains in the legs, and cramps. He could not take drink because it made him feel so bad. On leaving after a day's work he often reeled so much, from the effects of the benzol, in his gait, that he was taken to be drunk. The knee-jerks are now somewhat exaggerated (?) The heart sounds are normal, and his colour is a decided contrast to those who are working, or have recently been doing so, with the compounds spoken of.

CASE IV.—S. E. C., aged 17, was first seen by me on the occasion of my visiting the works in February, 1892. Mention will further on be made of the inspection then made of the *employés*. The following note was entered:—"Has been 'filling' for six months. Marked shortness of breath; very anæmic; lips bluish; pulmonary systolic murmur; loud venous hum; tips of the fingers feel cold to the touch, although she is not apparently conscious of it herself."

She was seen again on March 10th and examined with the ophthalmoscope; it is stated that the retinal veins were full.



Name F.E.

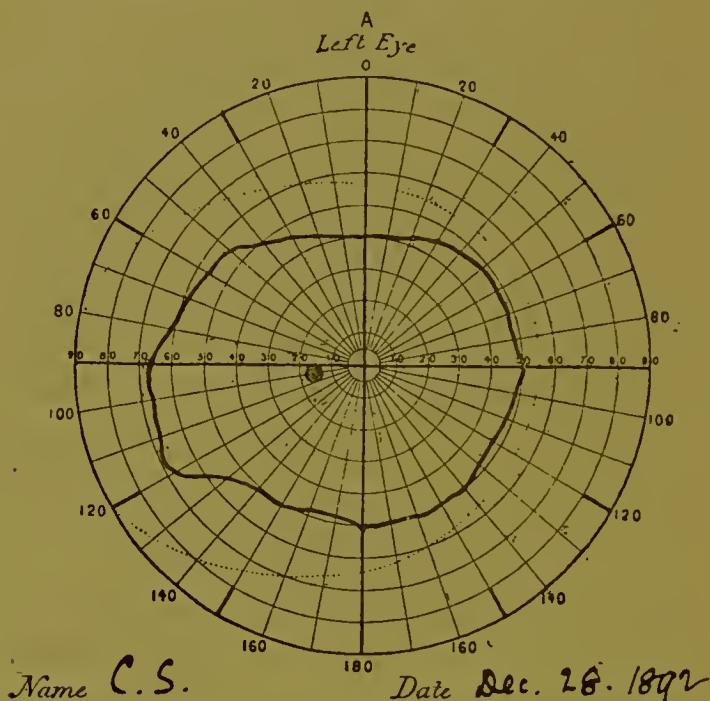
Date April 9, 1892

On April 12th she came over to see me for more complete examination. She had, it appeared, been employed at the works since August 12th, 1891. She now made no complaint of any impairment of sight and V= $\frac{5}{6}$ in each eye. The retinal arteries and veins were both rather full but especially the veins; the optic papillæ did not indicate any alteration. There was less difference in colour between the arteries and veins than usual; the veins were readily traced to the periphery. There was no scotoma for red. There was a faint systolic murmur over the pulmonary artery. She complained more of weakness than when she was first seen. She was away from work now on account of headache. She had loss of appetite but no nausea, there was numbness of feet which were also sore. She says now that she feels both feet and hands to be cold. There has been no injurious effect on menstruation, which has continued regular. Urine is black, almost like ink—specific gravity 1030. Urates: nothing to be seen under the microscope except amorphous urates; no blood detected with guaiacum test. The urine was submitted to spectroscopic examination, as was also the blood drawn from a needle prick of the finger; it was very thin and black looking. The results of this examination will be referred to presently.

July 23rd, 1892.—Her sight having become impaired she was brought to me to-day. She had been very ill on and off since her last visit in April. Yesterday afternoon she was taken ill and had to be sent home; she

could not walk and had to be driven. She had pains in the abdomen with nausea, but could not vomit. The dizziness caused her to reel like a drunken person. She could not walk and even fell off a stool on which she was sitting and tumbled also on getting into the trap which was to take her home. Complains now of dyspnoea. She feels very ill and doubtless is, for she looks it.

Her sight began to fail shortly after her visit to me in April. She could not read nor keep any account of the work which was done which was a part of her occupation. She does not think she is worse now than she has been for the last two or three weeks. There is increased pallor of face, mingled with a bluish tinge; the lips are blue. The colour of the hair has curiously altered from a golden to a sort of red. Urine has been very black lately. There is a hæmic murmur over the pulmonary artery, and a very marked *bruit de diable*; pulse is very soft and compressible; about 80, and regular. Vision: R. = $\frac{6}{37}$; L. $\frac{6}{24}$; she reads J 2 with each eye. Field of vision appears a good deal contracted concentrically; there is no scotoma for red or green, but there is a good deal of retinal hyperæsthesia, which interferes with trustworthy use of the perimeter. The retinal veins are full; the discs are pale, but the edges are sharp.



This patient could not be prevailed upon to enter the infirmary for treatment, and has not again been seen by me. I have, however, learnt that she has worked as much as she has been able, but has often been off at home ill; it seems as if these girls were almost compelled to continue working, as so many others are willing to do it. If complaints are made others will soon be found ready to take their places. Her sight when she was last heard of remained about the same as at my examination.

CASE V.—C. S., aged 56, was first seen by me on a visit to the explosive works on February 10th, 1892. He was then working as a "mixer," and he had been doing so for twelve months. The following notes were then entered: "He is less asphyxiated-looking than the other men are. Headache when a good deal in the fumes. Heart, normal. Notices that hands feel numb sometimes, and legs also up to knees. With ophthalmoscope retinal veins are seen to be much larger than arteries." Again on March 10th he was seen working at "mixing" and "grinding." He made no complaint of his eyesight at this time, but from what he told us later it would appear to have then attracted his attention. From other sources I heard of this man from time to time, and that he was suffering as it was said a good deal from the "powder." On December 28th, 1892, he

came to me on account of his eyesight, which he said was failing. Notes in more detail were then made as to his work and as to his condition, as follows:

He had now been a "mixer" for two years, "the worst job about the place." On two occasions he had been obliged to consult the doctor; the first time, soon after joining the works, was on account of shortness of breath, and the second time, in the spring of this year (1892), for giddiness and staggering; he could not walk many yards without falling. This lasted three or four days; he had previously been working for some days continuously. He had often noticed shortness of breath and giddiness after close application to his work, on other occasions besides the one just named. He had never had any vomiting. He said he had numbness of feet, and thought they were getting weaker. His breath was very short after exertion, and his limbs ached after walking. A glass of beer after a day's work acted on him in such a way as to make him stagger as if he were drunk, but he said "he felt all right in his head." His urine was dark, like porter, and had always been so since he had worked at the explosive works. The knee-jerks were normal; the sensation of the hands was normal, and there was no wasting of muscles. Nails were discoloured yellow, the conjunctivæ were yellowish, and there was a bluish tinge along the lips. He says his sight had been failing for twelve months, but it had been during the past few months that it had become so much worse. He could not now read the newspaper. $V: L = \frac{6}{\pi}$; $R = \frac{4}{5}$, and he read J 18. The optic discs were less rosy looking than normal, indeed somewhat greyish; the edges were also a little less defined; the veins were rather full, but there was no diminution in the calibre of arteries. The field of vision was contracted concentrically, there was no definite colour scotoma, but the central perception of red and green was somewhat dulled. He had been a smoker for forty years; the kind had been cut cavendish, and while formerly he consumed 2 ounces a week, for the last year it had been only 1 ounce a week. He had smoked less he told me because he had not had the inclination for it, and when he had been working in the mixing room he had scarcely had the "wind" for it.

It may be well here to refer to visits I was permitted to pay to an explosive factory. They enabled me to see the actual conditions under which the *employés* worked in the different processes; they afforded also opportunities for examining a number of those engaged in these processes with the benzol, and thus to gather further evidence as to its effect on the system. Dr. Cocking, Physician to the Sheffield General Infirmary, was kind enough to accompany me, and I am much indebted to him for a great deal that follows bearing on the medical aspects.

Men were seen engaged at grinding, and working in the mixing shed. They wore respirators over both nose and mouth. I saw also girls, several of them "filling;" respirators and gloves were employed, as with the men. There was a smell of bitter almonds in the shed. The powder was taken up with a small shovel, and put into cases made of waterproof paper, and afterwards it was rammed down with a rod. It was then weighed. The waterproofing or "dipping" was also seen. The cartridges were dipped into the liquid wax, weighed, and the weight stamped on each. The bitter-almond smell was also detected here, but much less so than in the mixing shed.

The following, who were engaged at work, were examined by us: Two men working as mixers; one C. S. has been already described (Case v).

R. C., aged 33, was another man engaged at "mixing." He looked half asphyxiated; face bluish; lips especially so. Shortness of breath and headache occasionally. Hands and fingers were discoloured, and toes also, but in a less degree. Heart: The apex beat was normal; faint pulmonary systolic *bruit*; marked *bruit de diable*, right less marked than left. Veins in the fundus oculi enlarged. Knee-jerk was normal. He was examined at a later date, especially with regard to the condition of the background of eye. Again, my note says veins decidedly larger than arteries, but arteries appear somewhat full. The urine was of a dark brown colour; specific gravity 1024.

Among the "dippers" and "fillers" the following were examined :

E. A., aged 17, has been working at "dipping" for two months; there is a venous hum and pulmonary systolic *bruit*. Has suffered from shortness of breath and palpitation; was badly affected a few days before examination. No complaint of numbness or dead feeling of extremities, but to the touch they feel cold; there is also blueness of finger tips. Here again the retinal vessels were noticed to be very full, but especially the veins.

A. H. had been five weeks "filling;" blue face, lips especially; pulmonary systolic *bruit*; no venous hum. Hands feel cold to the touch but she does not notice it herself. Breathlessness, especially on walking.

An opportunity of a more complete examination of this girl was afforded me a little later, and the following notes were then made :

She is 16 years of age, but has not yet menstruated. At the later date mentioned she had been working for four months. The retinal veins were found with the ophthalmoscope to be very much enlarged, like branches of trees; the arteries are less altered; the vessels somewhat obscure the discs. She makes no complaint of vision being affected; V=§ in each eye; there is weak degree of H. The edges of optic papillæ a little blurred; no red scotoma. Some blood was drawn from a needle-prick of a finger, and it was found to be very dark and thin. She has only been working three days a week lately, and the shortness of breath is less; no giddiness, no vomiting; the only complaint is shortness of breath; blueness of lips marked; the urine is very black; suffers from muscular weakness. Has been away from work for two days in consequence of "jumping of heart."

S. E. C., six months working as a "filler." The work with di-nitrobenzol has had no effect on menstruation. Her case (iv) has been detailed already.

E. A. B., a "filler;" pulmonary murmur and *bruit de diable*; retinal veins full, arteries not so much so; less marked than in most cases.

G. A., aged 18, has been working five months; is a "dipper;" pulmonary systolic and mitral systolic murmurs; has had rheumatic fever; no venous hum; no effect on menstruation.

E. W., aged 17, employed only three weeks; retinal veins full.

A. H., aged 16, working here for a week only; anæmia, shortness of breath; retinal veins very full, and arteries so, too, but in a less degree. She was taken ill as she was leaving the room at the works after my examination. She was afterwards seen by Dr. Twigg, the surgeon to the works, who kindly sent me a line as to her condition: "The girl whom you saw bad at the works the day you were there was taken very ill the same night. I was sent for and found her very delirious, complaining of great pain in her head (frontal) and shortness of breath, and I believe she had vomited several times before I saw her. The pulse was very quick (about 115), small, and compressible. I saw the retinal veins, which were very full."

M. W., aged 38, working for three weeks; retinal veins full, but less so than in other cases.

All these girls had the peculiar blue asphyxiated appearance; a typical one almost of the effects of the poison, but rather like that assumed often by those under the anæsthetic influence of ether.

The literature dealing with the injurious effects of nitro- or di-nitrobenzol is a small one. Isolated cases have been recorded. Messrs. Sykes and Twigg² mention the case of a man, aged 33, who came under their treatment on July 3rd, 1889, muddled, breathless, and cyanotic. He had begun to mix on June 28th (Friday), but Saturday and Sunday being holiday, he did not go again until July 1st. The same evening his wife noticed that he was blue, and he was unwell. They reported that the retinal blood vessels were "unusually dark and dilated." Mr. H. J. Knight reported in a succeeding number of the JOURNAL (vol. ii, p. 244) another case, being that of a man, aged 37. He went to the same works on July 2nd, when he was quite well. For

² BRITISH MEDICAL JOURNAL, 1889, vol. ii, p. 127.

the next two days he was engaged crushing and sieving the ingredients; on the fourth and fifth he was steaming the mixture ("mixing"), and on the evening of the latter date he was taken ill. Dr. J. Stokes, now of Sheffield, also in the *Lancet*, vol. ii, p. 368, 1889, mentions a case of poisoning from working with di-nitro from the same works. The first day at work the patient noticed that his hands and face were blue. The *Lancet*,³ moreover, refers to the case of a man who met his death after cleaning out a flue over the mixing room at the Gathurst works. The contents of the flues were said to be nitrobenzol, which is a very soft crystallisable substance. The men had to clean out this dangerous flue by turns, and were paid double wages. These fatal cases could be multiplied; others are reported as occurring at the works situated near Denaby.

The most complete articles dealing with the subject of the injurious effects of di-nitrobenzol are by the late Dr. Ross⁴ and Dr. Prosser White,⁵ of Wigan. The former, whose observations were on men only who used explosives (roburite) in the mine, would appear to attribute the symptoms met with to a kind of peripheral neuritis. He makes no definite statement as to the effects of the poison on the eye. He mentions the case of a man who, on combing his hair, looked up "at a mirror which was placed above the level of his eyes; and if when engaged in combing they remained raised for a short time a film came over them, and he could not see. Upon lowering the eyes the sight at once returned." This has, of course, no connection with nitrobenzol. The man was a collier, and clearly enough on raising his eyes and maintaining them in that way, as Dr. Ross mentions, the oscillations characteristic of miners' nystagmus were occasioned. This would, indeed, be a usual way of demonstrating the nystagmus if suspected to be present in any given case. Dr. White has, however, treated the whole subject in a most complete manner, more so, indeed, than any other observer that I am acquainted with. As the medical officer to large works manufacturing the species of explosives which have been mentioned as consisting in great measure of nitro or dinitrobenzol, he has for several years had good opportunities of studying the whole subject.

Of many of the topics dealt with here he has also treated, and at more length than I have attempted. He has also discussed briefly the effects on the eye of the poisonous influence of the benzol. In his former paper he stated the eye symptoms as negative, and added that Mr. Williams "found the fundus normal, with no restriction of the field of vision or for colour." In his more recent and much more comprehensive article he again quotes Mr. Williams, and goes somewhat beyond his former statements. Mention is made of four cases, in all of which had been observed sight failure. Details are only given of two of these, and then only briefly. The condition of neither visual field nor of colour perception is given. Dr. White, however, sums up as follows:—

"I think it is evident from these cases that nitrobenzol is capable of producing a peculiar form of retinitis with great defect of sight. In three of the four cases there were well-

³ 1889, vol. ii, p. 81.

⁴ *Medical Chronicle*, 1889, p. 89.

⁵ *Prov. Med. Journal*, 1892, p. 462. *Practitioner*, 1889, vol. ii, p. 15.

marked and unmistakable ophthalmoscopic signs consisting in darkness of colour of the fundus, great tortuosity of the veins in one or both eyes, with distinct effusion in two of the cases."

It may be here remarked that the fulness of the vessels was observed in my cases; but, as has been already described, the examination of a goodly number of other workers who, though suffering from the poisonous effects of the nitrobenzol, made no complaint of loss of sight, showed that the vessels were also generally if not always found engorged.

The first, however, to bestow any attention on the visual condition met with in these workers was Nieden, of Bochum.⁶ Twenty-five out of the 30 workpeople were more or less dangerously poisoned. They completely recovered. The symptoms observed were, he thinks, due to vasomotor paralysis in the heart and blood vessels and consequent overfilling of the veins—a theory which would account for the enlargement of the retinal veins, which in my observations was so generally found. In only one case did he find the eyes affected. He gives the case in the most careful detail. Vision was reduced to $\frac{1}{200}$; there was great concentric contraction of the visual field, but this was not the same for colours, which ran close up to that for white. He found venous hyperæmia of the retina, and effusion (circumscribed) surrounding the principal descending vein. The man slowly recovered and the ophthalmoscopic changes passed away.

We may now summarise the symptoms observed in the cases which have been here recorded. Taking the eye symptoms first, the characteristics are: failure of sight, often to a considerable degree, in a more or less equal extent on the two sides; concentric contraction of visual field, with, in many cases, a central colour scotoma; enlargement of retinal vessels, especially the veins; some blurring, never extensive, of edges of disc and a varying degree of pallor of its surface—the condition of retinal vessels spoken of being observed in workers with the di-nitrobenzol independently of complaints of defective sight. Cessation of work with the benzol leads to recovery. In Case II vision had continued defective, with contracted field, a considerable time after the exposure to di-nitrobenzol had ceased.

The symptoms mentioned are quite in accord with toxic amblyopia from other causes, whether it be tobacco, iodoform—as testified by the cases recently described by Priestley Smith⁷ and Valude⁸—or bisulphide of carbon, of which several cases are on record. The general condition of the patients was at first suggestive of this latter poison, and in my earliest case inquiries were made when he was first seen as to the possibility of the bisulphide in any way coming into his work. It at once became clear that the agent at work was a different one.

A word as to tobacco. My men were smokers, but before coming under observation they had reduced the quantity consumed, because, as they alleged, they were unable to smoke as much whilst at work with the benzol. Further than this, it is interesting to observe that in the first case, which was well observed for a long period, not only did

⁶ *Central. f. Augenheilk.*, 1888.

⁷ *Ophthalmic Review*, 1893, p. 101.

⁸ *Rev. d'Ophthal.*, 1893, p. 231.

vision become perfectly restored, but the field of vision became normal and the central scotoma for colour disappeared, whilst the tobacco was persevered in without restriction.

The general effects appeared to be chiefly exerted on the blood and nervous system. In some cases there were gastric symptoms also. With reference to the blood changes, the occurrence of very marked anæmia in girls, who lived practically in the country, and who worked in well ventilated rooms, was particularly striking. The symptoms and physical signs of anæmia in men, working under the same hygienic conditions, were perhaps still more noteworthy. That some other change, however, in the blood was also present is evidenced by the blueness of the lips and finger tips, which was observed in several of the cases. The colour of the urine was also remarkable.

The chief nervous symptoms were numbness of extremities and unsteadiness of gait. The numbness was not very marked, and in every case tactile sensation was normal. The knee-jerks were certainly not diminished in any case which was tested; on the contrary, in two cases it was doubtful if they were not increased. The unsteadiness of gait was noticed especially at the close of a day's work in the factory, and was much aggravated by the slightest indulgence in alcohol. The evidence of peripheral neuritis, referred to by Dr. Ross, was of the slightest description, and the ataxy appears to be due to an interference with the cerebral co-ordinating centres rather than to any affection of the cord or peripheral nerves. The effects of the poison on the sexual system was in some cases quite marked, but in no instance did it appear to occasion any menstrual irregularity, and this notwithstanding the anæmic condition of the females.

The di-nitrobenzol may, it appears, either be absorbed through the skin, ingested, or taken in through the air passages. What the poison then becomes I do not think has been satisfactorily ascertained, but its action on the blood is definite. Specimens drawn from the fingers of two of my patients were found to be thin and black-looking. Dr. MacMunn, of Wolverhampton, very kindly examined some specimens which I forwarded to him, as he did also of urine which as has been stated in relating the cases, was dark, almost black like porter. He writes me thus: "Spectroscopically all the specimens of blood sent showed nothing abnormal. Microscopically there was a distinct departure from the normal in the presence of large coloured corpuscles—megalo-cytes— $12\ \mu$ in diameter. The ordinary red corpuscles are smaller than normal, about 5 or $6\ \mu$ in diameter. The appearances were like those seen in pernicious anæmia. The urine of F. (Case II) was of a brown colour; this colour was not due to blood or bile, or to indican, but to some pigment belonging to the aromatic series—which, I cannot say. It also contained urobilin. I do not expect that we shall get any abnormal spectroscopic appearances from the blood except it should become so altered as to lead to the death of the patient. That is to say if the hæmoglobin was so broken up as to give a new spectrum life would not be possible."

These observations, which Dr. MacMunn so kindly made, are corroborated by those of Huber. In a lengthy paper in *Virchow's Archiv*⁹ he details his numerous experiments with

⁹ Abstract in *Journal of Chemical Society*, March, 1892, p. 366.

di-nitrobenzene on both cold and warm-blooded animals. The blood became of a dark chocolate colour, and the red corpuscles largely deprived of their pigment. Spectroscopic investigation showed an absorption band in the red reminding one of the similar band of acid hæmatine and of methæmoglobin, but not identical with either. He speaks of this as the di-nitrobenzene band, and considers that the benzene compound acts in a specific manner on the blood pigment. After large doses he found the urine to be brown in colour, and to contain a strongly reducing substance, and sometimes di-nitrobenzene itself was present. These animals referred to in Huber's observations were no doubt brought to the condition to which Dr. MacMunn refers as that in which spectroscopic appearances would be noticed in the blood.

The class of explosives under consideration find especial employment in coal mines, and this aspect of the subject remains for mention. The cases recorded by Dr. Ross in his article before alluded to were all men who were engaged in the mine, and became affected by the di-nitrobenzene in their employment underground. A fair number of miners have occasionally suggested to me that the roburite was injurious, more immediately after its first introduction than at present. I never was able, however, to get at any definite symptoms complained of. Generally the roburite was assigned as a cause of nystagmus instead of the commonly abused safety lamps.

Two important inquiries have taken place into the effects of roburite as representing the benzene group of explosives. At the Park Lane Colliery in Lancashire some two years or so ago the men alleged that working with roburite was injurious to their health, and they complained also of its greater cost as compared with gunpowder. A committee was appointed consisting of two medical men, nominated the one by the owners and the other by the men. Dr. N. Hannah and Dr. Mouncey were the medical men, and they selected as scientific assessor Professor H. B. Dixon, F.R.S., of Owens College. In a very able report the subject was treated completely. They were inclined to attribute the undoubted cases of nitrobenzene poisoning which had been brought under their notice to improper handling of the cartridges. They also insist on the need for insuring complete combustion, and after discussing the symptoms met with say that if stringent care is taken by the manager, shotfirers, and colliers, the use of roburite will not add to the harmful conditions under which the miner works. Means for removing the fumes from the working face were also insisted upon.

In Durham, too, the subject has been taken in hand. The Coalowners' Association and the Miners' Association in that county appointed a committee, who again selected Drs. Drummond and Hume, with Professor Bedson, as professional advisers. This report also is a very complete one. Professor Bedson deals in the fullest manner with the chemical aspect, and his examination of the fumes in the pit after explosion appears to have been most exhaustive. He says that "in some cases after the firing of roburite the odour of nitrobenzene was observed, but beyond this I obtained no evidence of nitrobenzene nor of any similar product." He further alludes to the danger in the case of roburite, as in similar explosives, to be found in the fact that the fumes produced are almost entirely gaseous, and their consequent in-

visibility may lead the miner to return to his work sooner than he would if, for instance, gunpowder was used. The fumes are, however, he finds by experiment, quickly dispersed, but he thinks a miner should not return to the coal face until five minutes have elapsed after the shot had been fired. The medical men give as their opinion that the nitrobenzene derivatives which give the fumes their characteristic odour exist in too minute quantities to be hurtful. But it is interesting to note the symptoms they found in the men who alleged that they had suffered through being exposed for lengthened periods to the fumes of roborite amongst the coal which had been brought down. "The symptoms described by them were such as are popularly spoken of as 'bilious symptoms,' and the more severe attacks seemed to have been accompanied by slight jaundice. They had headache, occasional vomiting, dizziness, want of appetite, want of sleep, or occasional drowsiness." They were disposed to think these are in great measure symptoms by no means uncommon in miners, and further they do not assign any of the ailments complained of by the men to any poisonous or specially hurtful influence of the explosive. For my part, I should be compelled to take a different view, and to recognise in the symptoms mentioned those which have been described in the earlier part of this paper as belonging to the milder effects on the system of di-nitrobenzene. And I should go further, for recognising the fact that the injurious influence of the poison can be exerted under certain conditions when explosives of which it forms a main constituent are employed in the mine, would look upon them as preventable, and urge attention to care in handling the cartridges, insuring perfect combustion and the ready escape of the fumes by ventilation from the working faces.

In conclusion, I will mention the suggestions for "prevention" I drew up at the invitation of Captain H. Smith and Professor Dupré for their report to which I have before alluded:

"The preventive means which may be adopted in places where the di-nitrobenzol is used may be placed under the following heads:—

"1. That the different processes should as much as possible be conducted in the open air, or in large, well-ventilated sheds.

"2. That in the 'mixing' closed vessels should as much as possible be employed.

"3. Fans, which have been adopted in other trades with great advantage, might also in this one be of service.

"4. Respirators are in use, but their employment is, as far as I am aware, optional. Those protecting both the nose and mouth are, up to a certain point, of service. I do not think they a sufficient safeguard against the fine vapour entering the respiratory system. It occurred to me that during the process of 'mixing' especially it might be possible to shut the workman off from the vapour and fine dust by means of a kind of diving-bell apparatus, with a communication behind to the outer air. A mask, such as has been used, I believe, in Germany, might answer the objects desired.

"5. Handling by the bare hand or direct exposure of the skin should be avoided. The 'filling' could perhaps be performed automatically. The hands should, moreover, be protected by gloves. These should be capable of being

cleaned, and possibly india-rubber might be used by preference. The cleaning is an important matter, because gloves put on with any of the substances clinging to the interior, as would be the case after they had been in use for some time, would allow of absorption taking place under the still more favourable circumstances afforded by the warmth and moisture of the hand. Special clothing should be provided, the workmen and women being compelled to change their clothes on entering and retiring from work. Dressing rooms should be provided, and the importance of washing enforced. Food should only be partaken of away from the sheds where the 'mixing,' 'filling,' etc., take place, and particularly is it important to insist on a free use of washing before meals, and the special clothing should also be removed. These are measures which have been found of service in the different occupations in which lead, for instance, is employed.

"Lastly, as regards the use of these explosives in mines. Symptoms have been recorded as occurring in miners having to do with cartridges containing this substance in the pit. They have much resembled the milder symptoms met with among the workers at the factories where the explosives are made, though it has often appeared that care has been taken that the contents of the cartridges should not come in contact with those employing them. It has, however, been pointed out that in the manufacture the 'dippers' have been recognised as being liable to be affected, and, as has been said, it would appear as if the poison is a very subtle one. Not only, therefore, should means be taken to prevent any of the powder adhering to the outside of the cartridges, but it appears very essential that they should be made in such a way as to ensure that combustion should be complete, and that their use should be restricted as much as possible to well ventilated places, so that currents of air would speedily dilute and carry away any deleterious vapours."

As a result of the report by Dr. Dupré and Commander Hamilton Smith, the Secretary of State has certified (Factory and Workshops Act, 1891) that, in his opinion, the manufacture of explosives in which di-nitrobenzol is used is injurious to health, and notice to observe "special rules" has been served on the different manufacturers. These "rules" are those recommended in the report alluded to by Dr. Dupré and Commander H. Smith.

